SCIENCE BASED TARGETS NETWORK
GLOBAL COMMONS ALLIANCE

FRESHWATER

# TECHNICAL GUIDANCE

GROUNDWATER

DRAFT FOR PUBLIC CONSULTATION OF V2 (2025)

STEP

3

MEASURE, SET & DISCLOSE

Hi Everyone,

Thanks for reviewing the global groundwater update!

*"Today, more than two billion people and nearly half of all freshwater ecosystems depend on groundwater for at least some of their needs. Groundwater also boosts food supply by providing 38% of the water used to irrigate crops.*

*Unfortunately, in many places we are extracting groundwater faster than it is being replenished by natural or managed recharge. This overdraft is driving groundwater depletion, or a diminishing volume of water in aquifers—a fast-increasing problem around the world. Many regions that rely on groundwater do not regularly measure groundwater levels to detect overuse, and even more concerning, few governments have set controls to keep groundwater extraction at sustainable levels.*

*Even though the volume of groundwater remaining in an aquifer may be enormous, groundwater depletion can become a very serious problem long before an aquifer is fully emptied, simply because relatively small drops in the aquifer level can trigger myriad adverse impacts."*

- Excerpt from Sustainable Groundwater Management for Agriculture (2022) by Brian Richter and Melissa D. Ho

This document builds on the current SBTN Freshwater Step 3 guidance (V1.1) by enabling a globally developed modeling approach to target setting specifically for groundwater. Unchanged sections are not included to help focus review.

**Primary Resources to Support Reviews**

1. Proposed groundwater technical guidance update ***with*** tracked changes.
2. Proposed groundwater technical guidance update ***without*** tracked changes.
3. Public consultation questions for reviewers
4. Slide deck describing technical underpinnings
5. Recording of slide deck presentation (13 minutes)

**Supplemental Resources**

- SBTN Corporate Manual (primer for technical guidance)
- SBTN Step 1 Technical Guidance
- SBTN Step 2 Technical Guidance
- SBTN Freshwater Step 3 Technical Guidance (v1.1)
- SBTN Freshwater Step 3 Global Water Quantity Model (Hogeboom)

# Contents

# Introduction Step 3: Freshwater

## 1.2 Freshwater method scope

Table 1: Summary of content included in this second version of methods to set science-based targets for nature: Freshwater.

| Content included | Content not included (i.e., to be included in subsequent versions) |
|---|---|
| Freshwater Quantity | |
| • Surface water flows<br>• Groundwater levels | • |
| Future projections | |
| • Consideration of forward-looking scenarios, including how future climate change will impact **groundwater levels** | • Consideration of forward-looking scenarios, including how future climate change will impact water availability and quality |

**Table 2**: Minimum data requirements for pressure baseline measurements.

| | Data requirement | Data sources | Unit of measurement |
|---|---|---|---|
| **FRESHWATER QUANTITY** | | | |
| **Direct operations** | Nature of water source (surface or groundwater) | Water provider | |
| | Primary/direct measurements | Water meter | Volume per month, e.g., ML/month |
| **Upstream** | Nature of water source (surface or groundwater) | Water provider | |
| | Primary/direct measurements (preferred, if available) | Water meter or water diversion | Volume per month, e.g., ML/month |

# Minimum data requirements

## 2.1 Freshwater quantity pressure baseline

**Direct operations**
Water quantity pressures from direct operations *must* be calculated from **primary data**, i.e., direct site-specific measurements from water meters. The required units are the average withdrawal volumes over the course of each month. Sites that have nonconsumptive water use, such as cooling water, *may* report net withdrawals (i.e., gross withdrawals minus return flow), but only in cases where the nonconsumptive flow is returned at the same time and location as the withdrawal and provided that the return does not significantly impact key freshwater quality parameters. For sites where groundwater depletion has been identified as a concern in the value chain assessment in Step 1: Assess,[x] companies must also identify whether their water supply originates from surface water and/or groundwater.

**Upstream**
Water quantity pressures from upstream activities can be calculated either from primary data (**direct measurements**) or from **secondary data (modeled estimates)** using blue-water footprint(s) or other models of water use.

The required units for primary data are average withdrawal volumes over the course of each month. The units for secondary data sources are either monthly or annual average water consumption, depending on the method used. Similar to sites using primary data, sites using secondary data that have nonconsumptive water use may report net withdrawals, but only in cases where the nonconsumptive flow is returned at the same time and location as the withdrawal and provided that the return does not significantly impact key freshwater quality parameters. For sites where groundwater depletion has been identified as a concern in the value chain assessment in Step 1,[w] companies must also identify whether their water supply originates from surface water and/or groundwater.

# Process for setting Freshwater science-based targets

# Step 3a. Hydrological model selection

## 3.1 Model selection

### 3.1.1 OUTLINE OF LOCALLY AND GLOBALLY DEVELOPED MODELING APPROACHES

These approaches can be summarized as follows:

- **Locally developed modeling approach**: Targets are based on hydrological models specific to a given basin (i.e., developed for that basin), paired with locally based thresholds, emphasizing those which are recognized by the local basin management authority or water resources management agency. In some cases, particularly for groundwater, local models may not always be superior to global models due to limitations in model domain of other factors. Therefore, stakeholder consultation is a critical part of ensuring that the model and threshold chosen are appropriate and compatible with corporate data.

- **Globally developed modeling approach**: Targets are based on global hydrological models and paired with thresholds that are either globally defined (i.e., freshwater quality thresholds) or based on the results of global models (i.e., freshwater quantity thresholds). Local stakeholder consultation is used to ensure alignment on the application of a global model in a given basin. In cases where a local model and threshold are not available, global models represent the best available science to inform science-based targets.

Identifying and consulting with relevant stakeholders, including national and local organizations and institutions, is critical to the selection of the modeling approach. Section 3.1.2 provides more information on model selection.

The remainder of Section 3.1 documents the model selection process. It begins with a description of model selection to determine targets protective of surface water thresholds (i.e., e-flows), continues with a discussion of stakeholder engagement, and concludes with a description of model selection to determine targets protective of groundwater thresholds.

### 3.1.2 SURFACE WATER MODEL SELECTION DECISION TREE

**Figure 3** (found in the current technical guidance): This decision tree illustrates the process to select a surface water modeling approach (either globally determined or locally determined) through a series of database and stakeholder consultations.

Figure 3 shows a decision tree that companies can use to guide their selection of a locally or globally developed modeling approach to determine targets protective of surface water thresholds (Section 3.1.4 describes selection of models for groundwater). Companies are required to follow this decision tree to determine which approach is to be applied for each basin in whichever priority sites have been identified under Step 2: Interpret & Prioritize.

**Tasks 1 & 2. Identify the basin of activity or location and Consult hydrological model database for local models**

The first stage of the consultation process consists of checking the SBTN Basin Threshold Tool (which is under development) for available local models and thresholds. This tool contains local models and thresholds that have either been used by other companies that have set and have had externally validated science-based targets in the basin or have been identified and approved through research efforts by the SBTN Freshwater Hub. SBTN will populate this tool as companies set and validate targets using local models and thresholds, so that coverage will increase as time goes on.

**Task 3. Consult national stakeholders**

An appropriate local model is one that, in the opinion of the consulted stakeholders, meets most of these criteria:

- safeguards aquatic ecosystems and their ecological services by including environmental flows and natural flow regime alterations;
- accounts for major anthropogenic disturbances to surface flows, for example from dams or canals (cross-basin transfers);

- accounts for (allocated) water resource use rights and for acceptable water access for the population;
- accounts for major anthropogenic fluctuations in groundwater levels (for water quantity only);
- accounts for local, national, or international water quality standards for nutrient pollutants (for water quality only);
- accounts for major anthropogenic sources of nutrient pollutants in the basin (for water quality only);
- has been ground-tested in the basin or its predictions have been corroborated by observed data;
- if it is a combined surface water and groundwater model (or "integrated" model), a designated water management agency *must* apply the model to define water use (see groundwater selection requirements in Section 3.1.3).

**Task 4. Consult national stakeholders**

Global modeling approaches are considered appropriate to be used in a given basin if, in the opinion of local stakeholders:

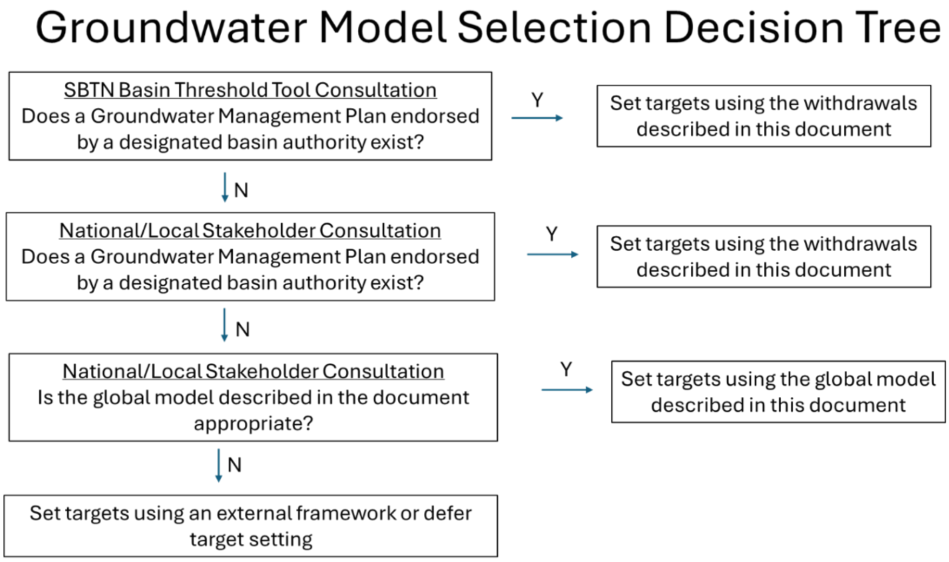
- the basin does not have major inter-basin water transfers, dams, or other diversions that are not accounted for by the model;
- the basin does not have major disputes as to water rights or water access that are not accounted for by the model;
- the basin does not have major anthropogenic disturbances to nutrient flows that are not accounted for by the model;
- the basin does not have threatened (terrestrial or freshwater) species or ecosystems that are highly dependent on water flows beyond the global model's considerations for e-flows;
- the basin does not have threatened (terrestrial or freshwater) species or ecosystems that are highly sensitive to freshwater nutrient concentrations or dissolved oxygen (DO) concentrations;
- the global model has not been challenged by local stakeholders in the past for being inaccurate to the water regime in the basin.

### 3.1.3 GROUNDWATER MODEL SELECTION DECISION TREE

For sites where groundwater depletion has been identified as a concern, companies must also select a groundwater model. Figure 4 shows a decision tree that companies can use to guide their selection of a locally or globally developed modeling approach to determine targets protective of groundwater thresholds.

The groundwater model selection decision tree is a scaled-down version of the surface water model selection decision tree shown previously in Figure 3. The simplification is because the *only* acceptable local modeling approach for groundwater is when a designated management agency has applied a model to define groundwater abstraction as part of a groundwater management plan. This requirement also applies to combined surface water and groundwater models (or "integrated" models).

**Figure 4**: Decision tree illustrating the process to select a groundwater modeling approach




The groundwater model selection process begins with checking the SBTN Basin Threshold Tool (which is under development) for an available local model that has been applied by a designated management agency as part of an accepted groundwater management plan. Should such a model exist, company-specific allowable withdrawals specified in the plan should be used as the basis for setting targets.

If the SBTN basin threshold tool does not show the presence of a local model that has been applied by a designated management agency as part of an accepted groundwater management plan, the search for such a model/plan should be extended to the national and local stakeholders discussed above. Should this stakeholder consultation identify a model/plan, company-specific allowable withdrawals specified in the plan should be used as the basis for setting targets.

Should no model/management plan be identified in the previous steps, companies can assess whether the global groundwater modeling approach described in Section 3.3.1 is appropriate to use in the basin of interest using the same criteria described above in Section 3.1.2. Additionally, relevant stakeholders must be consulted to determine whether the global groundwater model is appropriate for "local aquifers in higher and steeper terrain."[x] If the global modeling approach is appropriate for the basin, the company is required to use this modeling approach to set its target. Otherwise, the company can conclude that no appropriate modeling approach, either local or global, is available for the basin. Further guidance is included below on how to proceed.

# Step 3b. Baseline pressure calculation

## 3.2 Baseline values on relevant pressures

### 3.2.1 SPATIAL SCALE

Freshwater science-based targets are set at the river basin level. River basins are defined at different degrees of spatial aggregation depending on the number of tributaries feeding into the downstream water body (e.g., by using the Pfafstetter Coding System, a hierarchical method of coding river basins—see Glossary for further definition). Before taking baseline measurements, companies must define the spatial scale (i.e., basin and level of aggregation) for which targets will be set.

The basin level used by companies will be determined by the modeling approach they select (see Section 3.1) and the pressure targeted (i.e., withdrawals and/or pollution), and may be a finer scale than used for the Step 1 and 2 methods. For example, in the globally developed approach for freshwater quantity that applies Hogeboom's water quantity global model[23] and (presumably) de Graaf's global linked surface water groundwater model (GSGM),[y] Pfafstetter Level 5 basins would be used; whereas in the globally developed approach for freshwater quality that applies McDowell's (2020),[24] results in the SBTN State of Nature Water Layers app, Pfafstetter Level 6 basins would be selected. The basin level for the locally developed approaches will depend upon the specific local model.

**Globally developed modeling approach**

The basin levels for setting Freshwater science-based targets using a globally developed modeling approach are directly specified and vary depending on the pressure targeted and chosen model.

- For Freshwater Quantity targets, companies must use Level 5 basins for setting targets, consistent with the scale of data provided by Hogeboom's water quantity global model or (presumably) de Graaf's GSGM.

**Task 7. Calculate baselines**

### 3.2.2 FRESHWATER QUANTITY BASELINE VALUE

Once the spatial scale for each baseline is selected, the company can calculate its baseline value(s). The aggregation of total water withdrawals from all the company's activities within a specified basin level and time period is recorded as its "water quantity baseline value" in this basin. The company may be able to leverage data and information collected in the value chain assessment in Step 1: Assess to calculate its Step 3 baseline.

The output of this step in the target-setting process is a measurement of a company's baseline withdrawals as an indication of its overall water use for each basin. This baseline value of present-day withdrawal will be used to calculate the company's target withdrawal for each basin based on the basin's relevant thresholds.

**Data disaggregation requirements**

Primary (direct measurement) and secondary (modeled estimates) data must be separated for baselining and target setting. Direct operations and upstream data must also be disaggregated by primary or secondary data for target setting in a given basin. Note that upstream sites will often be more reliant on secondary data. Primary and secondary data may be combined only for target language according to the Claims Guidance.

For sites where groundwater depletion has been identified as a concern, companies must report separate baselines for water that comes from surface water and groundwater for either separate targets or a combined target using the more stringent of two target pathways in Section 3.3.1. In instances where disaggregation may not be possible or is controlled by a water provider, companies must follow the Groundwater Levels pathway for target-setting in Steps 3c & 3d (Section 3.3.1).

# Steps 3c & 3d. Environmental thresholds identification and Freshwater Quantity target setting

## 3.3 Setting Freshwater Quantity targets

After companies have calculated Freshwater Quantity baseline values for all priority sites in a given basin, they can begin to define targets for Freshwater Quantity for direct operations and upstream activities (the Freshwater Quantity targets are shown as a conceptual diagram in Figure 5). To set targets, they must next calculate the maximum allowable level of basin-wide withdrawals (water withdrawals corresponding to all water users in a given basin), specified in terms of the required percentage reduction in the present-day rate of withdrawal. Table 3 summarizes the model results to be used for target settings across different types of basins. Target setting concludes by allocating a portion of this amount to the company's operations and suppliers. Targets are to be set for each basin in which priority sites have been identified in Step 2.

**Tasks 8 & 9. Apply hydrological data for the basin and Calculate required, basin-wide pressure reductions**

### 3.3.1 MAXIMUM ALLOWABLE LEVEL OF BASIN-WIDE WITHDRAWALS

**Direct application of model**

In contrast with the Back-calculation from existing results option, the *Direct application of model* option does not require the assumption that the rate of withdrawal at any given time is directly reflected as a reduction in stream flow. This makes the *Direct application of model* option suitable for situations where the protection of groundwater levels is an important consideration. Furthermore, this option is better suited for situations where pressures other than withdrawals (e.g., dams) are responsible for the non-attainment of e-flow requirements, as it allows the effect of alternative dam operations to be considered.

It is important to note one acceptable variant to the *Direct application of model* approach, where the model is applied by the designated management agency to define maximum company-specific withdrawals that are protective of nature. Companies do not need to apply the model in this situation and can use the specified allowable withdrawal as the basis for their freshwater quantity target.

**Back-calculation from existing results**

$$\text{\% Reduction in basin-wide withdrawal required} = \frac{\text{Excess withdrawal}}{\text{Present-day withdrawal}} \times 100$$

Equation 1

**Globally developed modeling approach: Two pathways**

To support the setting of globally developed Freshwater Quantity targets, two methodological pathways have been established corresponding to the following environmental thresholds:

1. Surface Water Environmental Flows
2. Groundwater Levels

Each pathway provides a different approach for determining the required reduction in basin-wide water withdrawals based on thresholds protective of nature. The Surface Water pathway uses the global model in Hogeboom et al, (2020), while the Groundwater pathway intends to use results from the global linked surface water groundwater model (GSGM) (de Graaf et al, 2019). In instances where disaggregation may not be possible (i.e., insufficient data from the water provider to separate), companies must follow the Groundwater Levels pathway.

1. Surface Water Environmental Flows

The Surface Water pathway can apply to sites where either **surface water *<u>and/or</u>* groundwater withdrawals** are affecting the attainment of environmental flows. While both global models described in this document consider surface water and groundwater interactions, Hogeboom et al. (2020) use a more robust approach to determining environmental flow status, which is a central component of freshwater ecological integrity.

Globally developed Freshwater Quantity targets to protect e-flows must be defined using the results from Hogeboom's water quantity global model to define the required reduction percentage in basin-wide withdrawals that will attain the desired stream flows.[40]

The approach is similar to that described for the locally developed approach, where the required reduction percentage is based on the ratio of excess withdrawals to present-day withdrawals (i.e., Equation 1). The difference is that the globally developed approach uses the results of global hydrologic models to calculate excess and present-day withdrawals rather than locally developed data and therefore may reflect an over- or under-estimation of actual water scarcity/availability conditions. As discussed below, all technical steps are being automatically conducted within the model framework such that a company only needs to specify the basin(s) of interest, and the required basin-wide reduction will be provided.

Hogeboom et al. (2020) estimated natural stream flow by extracting results from three global hydrologic models[41] to define ensemble mean monthly flow regimes for streams worldwide in the absence of any withdrawals. They determined e-flow requirements based on the ensemble mean results of three widely accepted methods[42] for establishing e-flow requirements to be set aside in each basin to ensure proper aquatic ecosystem functioning on a monthly basis. They then calculated the amount of water available for human use by subtracting e-flow requirements from natural flow regimes for each basin in the world and for each month in the period 1970–2005.

Hogeboom's water quantity global model is updating the above analysis to calculate the required reduction percentage at the basin level for each month of the period 1990–2019 using Equation 1, and subsequently to define the percentage reduction required for each month such that e-flow requirements would be attained approximately 75% of the time.[43] These results are provided for each Pfafstetter Level 5 basin worldwide in an easy-to-use format. These reduction percentages are to be used as the basis for target setting if the globally developed approach is taken using the Hogeboom model.

2. Groundwater Levels

For groundwater, the approach mirrors that of the Surface Water pathway: Freshwater Quantity targets are defined by estimating the required percentage reduction in groundwater withdrawals to achieve sustainable aquifer use, based on global hydrologic model outputs rather than locally developed data.

Required reductions in basin-wide withdrawals to specifically protect groundwater levels must be taken from global linked model for surface water and groundwater model specified by SBTN (presumably GSGM). The GSGM couples the global hydrology and water-resources model (called PCR-GLOBWB) with a two-layer global groundwater flow model based on MODFLOW that simulates lateral groundwater flow. GSGM simulates hydrological processes at 5 arc-minute resolution at a daily time-step for surface water and a monthly time step for groundwater (de Graaf et al., 2019).

GSGM model results will be processed for scenarios representing the period 2011–2100 to generate the following outputs at the Pfafstetter Level 5 basin scale:

- **Dynamically stabilize groundwater only**: Minimum percent reduction in basin-wide groundwater pumping required to result in dynamically stable groundwater levels (i.e., no long-term decline) regardless of depth.
- **Groundwater dependent ecosystem**: Percent reduction in basin-wide groundwater pumping required to result in dynamically stable groundwater levels (i.e., no long-term decline) above rooting depths for vegetation that commonly rely on groundwater (or "root-zone")[z].

All technical calculations are embedded within the groundwater model outputs, so users only need to specify the basin(s) of interest to receive the recommended basin-wide reduction percentage. This model may similarly reflect over- or underestimation relative to actual local aquifer conditions and should be applied with awareness of such limitations.

For basins where groundwater depletion has been identified as a concern, the required reduction in withdrawals may differ between water sourced from groundwater versus water sourced from surface water. Table 3 shows which model results to use for target setting for different types of basins.

A. **For basins where e-flow is a concern but groundwater levels are not**: Groundwater pumping and surface withdrawals must both be reduced by the percentage specified by the selected surface water model (local model or Hogeboom et al. global model).

B. **For basins where groundwater levels (and e-flow) are a concern, <u>but not classified</u>**

**as a groundwater-dependent ecosystem**: Reductions in groundwater withdrawals must be based on the more stringent requirement between 1) the reduction needed to maintain stable aquifer levels, and 2) the reduction necessary to protect e-flow.

C. **For a groundwater-dependent ecosystem (and e-flow is a concern)**: Groundwater withdrawal reductions must be based on the most restrictive level between 1) the reduction required to maintain aquifer levels above the root zone, and 2) the reduction required to protect e-flows.

**Table 3**. Model results to use for different pathways and types of basins

| **1. Percent reduction in surface water withdrawals** |
|---|
| Reduction required by the selected surface water model (local or Hogeboom) |

| **Type of basin** | **2. Percent reduction in groundwater pumping** |
|---|---|
| **A. E-flow a concern, groundwater levels not** | Reduction required by the selected surface water model (local or Hogeboom) |
| **B. Groundwater (and e-flow) a concern, but not a groundwater-dependent ecosystem** | Reduction required by the selected local groundwater model; otherwise most restrictive level from:<br>• Reduction required to maintain stable aquifer levels (GSGM)<br>• Reduction required to protect e-flow (Hogeboom) |
| **C. Groundwater-dependent ecosystem (and e-flow is a concern)** | Reduction required by the selected local groundwater model; otherwise most restrictive level from:<br>• Reduction required to maintain aquifer levels above the root zone (GSGM)<br>• Reduction required to protect e-flow (Hogeboom) |

### 3.3.5 VALIDATION CRITERIA FOR FRESHWATER QUANTITY TARGETS

TO UPDATE AFTER TECHNICAL GUIDANCE FINALIZED

## Endnotes

w. In Step 1, companies will use pressure-sensitive state of nature (SoN) indicator scores from 1) Hogeboom's water quantity global model in the unified SoN layer, and 2) (presumably) Gerdener's (2023) global land water storage (GLWS 2.0) in WWF's Water Risk Filter to determine whether e-flows or groundwater levels are concerns.

x. A limitation of the (presumed) de Graaf global groundwater model is that "the grid-resolution (5 arc-minutes, approx. 10 km at the equator) is still too coarse to capture local aquifers in higher and steeper terrain."

y. This model does not yet exist for SBTN application.

z. This dataset has not been prepared yet.

## References

de Graaf, I. E., Gleeson, T., Van Beek, L. P. H., Sutanudjaja, E. H., & Bierkens, M. F. (2019). Environmental flow limits to global groundwater pumping. *Nature*, 574(7776), 90-94. https://doi.org/10.1038/s41586-019-1594-4

# Glossary

**Groundwater-dependent ecosystems**: ecosystems that rely on groundwater for their continued existence.

SCIENCE BASED TARGETS NETWORK
GLOBAL COMMONS ALLIANCE